

**PROTECTION PRODUCTS - RailClamp®**
**Description**

RailClamp® TVS arrays are ultra low capacitance ESD protection devices designed to protect high speed data interfaces. This series has been specifically designed to protect sensitive components which are connected to high-speed data and transmission lines from overvoltage caused by **ESD** (electrostatic discharge), **CDE** (Cable Discharge Events), and **EFT** (electrical fast transients).

The RClamp®0522P and RClamp®0524PA have a typical capacitance of only 0.30pF between I/O pins. This allows it to be used on circuits operating in excess of 3GHz without signal attenuation. They may be used to meet the ESD immunity requirements of IEC 61000-4-2. The RClamp0522P is designed to protect two lines, while the RClamp0524PA will protect four lines.

The RClamp0522P is in a 6-pin SLP1610P4 package. It measures 1.6 x 1.0 with a nominal height of 0.58mm. The RClamp0524PA is in a 10-pin SLP2510P8 package. It measures 2.5 x 1.0 with a nominal height of 0.58mm. The leads are spaced at a pitch of 0.5mm and are finished with lead-free NiPdAu. They are designed for easy PCB layout by allowing the traces to run straight through the device. The combination of small size, low capacitance, and high level of ESD protection makes them a flexible solution for applications such as HDMI, DisplayPort™, MDDI, and eSATA interfaces.

**Features**

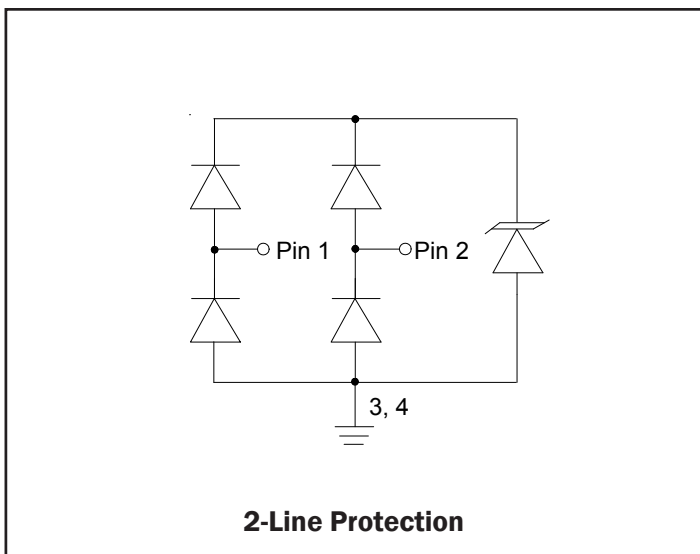
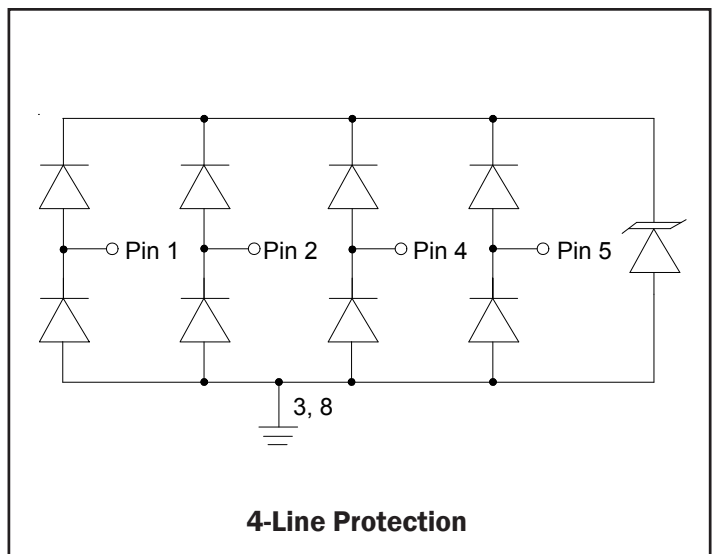
- ◆ ESD protection for high-speed data lines to **IEC 61000-4-2 (ESD) ±17kV (air), ±12kV (contact)**
- ◆ **IEC 61000-4-5 (Lightning) 5A (8/20µs)**
- ◆ **IEC 61000-4-4 (EFT) 40A (5/50ns)**
- ◆ Package design optimized for high speed lines
- ◆ Flow-Through design
- ◆ Protects two or four I/O lines
- ◆ Low capacitance: **0.3pF** typical (I/O to I/O)
- ◆ Low clamping voltage
- ◆ Low operating voltage: 5V
- ◆ Solid-state silicon-avalanche technology

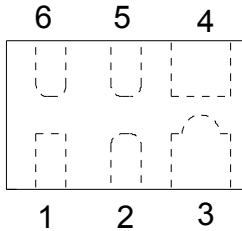
**Mechanical Characteristics**

- ◆ SLP1610P4 6-pin package (1.6 x 1.0 x 0.58mm)
- ◆ SLP2510P8 10-pin package (2.5 x 1.0 x 0.58mm)
- ◆ Pb-Free, Halogen Free, RoHS/WEEE Compliant
- ◆ Lead Pitch: 0.5mm
- ◆ Lead finish: NiPdAu
- ◆ Marking: Marking Code
- ◆ Packaging: Tape and Reel

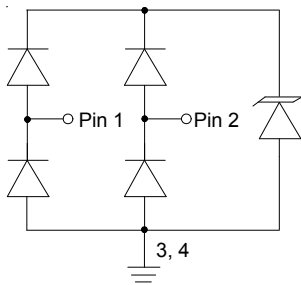
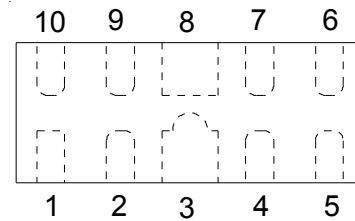
**Applications**

- ◆ High Definition Multi-Media Interface (HDMI)
- ◆ Digital Visual Interface (DVI)
- ◆ DisplayPort™ Interface
- ◆ MDDI Ports
- ◆ PCI Express
- ◆ eSATA Interfaces

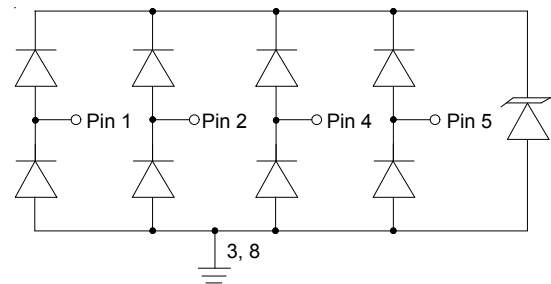
**Circuit Diagram - RClamp0522P**

**Circuit Diagram - RClamp0524PA**


**PROTECTION PRODUCTS - RailClamp®**
**Pin Identification and Configuration**
**RClamp0522P**


| Pin   | Identification                           |
|-------|--|
| 1 - 2 | Input Lines                              |
| 5 - 6 | Output Lines<br>(No Internal Connection) |
| 3 - 4 | Ground                                   |

**SLP1610P4 Pin Configuration (Top View)**

**Circuit Diagram**
**RClamp0524PA**


| Pin         | Identification                           |
|-------------|--|
| 1, 2, 4, 5  | Input Lines                              |
| 6, 7, 9, 10 | Output Lines<br>(No Internal Connection) |
| 3, 8        | Ground                                   |

**SLP2510P8 Pin Configuration (Top View)**

**Circuit Diagram**
**Ordering Information**

| Part Number     | Number of Lines | Qty per Reel | Reel Size |
|-----------------|-----------------|--------------|-----------|
| RClamp0522P.TCT | 2               | 3000         | 7 Inch    |
| RClamp0524PATCT | 4               | 3000         | 7 Inch    |

RailClamp and RClamp are marks of Semtech Corporation.

**PROTECTION PRODUCTS**
**Absolute Maximum Rating**

| Rating   | Symbol    | Value            | Units |
|--|-----------|------------------|-------|
| Peak Pulse Power (tp = 8/20μs)                                 | $P_{pk}$  | 150              | Watts |
| Peak Pulse Current (tp = 8/20μs)                               | $I_{pp}$  | 5                | A     |
| ESD per IEC 61000-4-2 (Air)<br>ESD per IEC 61000-4-2 (Contact) | $V_{ESD}$ | +/- 17<br>+/- 12 | kV    |
| Operating Temperature  | $T_J$     | -55 to +125      | °C    |
| Storage Temperature  | $T_{STG}$ | -55 to +150      | °C    |

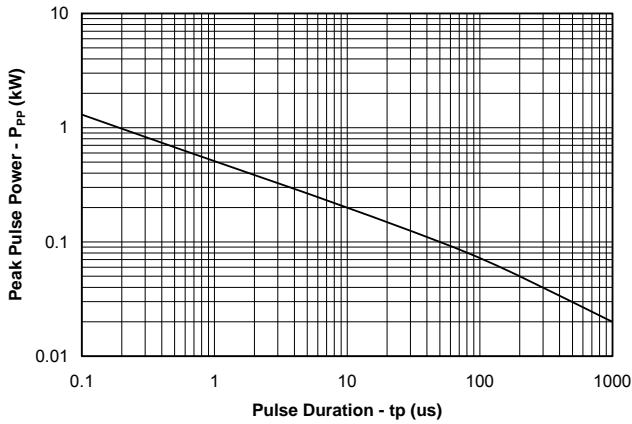
**Electrical Characteristics (T=25°C)**

| Parameter                 | Symbol    | Conditions  | Minimum | Typical | Maximum | Units |
|---------------------------|-----------|---|---------|---------|---------|-------|
| Reverse Stand-Off Voltage | $V_{RWM}$ | Any I/O pin to ground                               |         |         | 5       | V     |
| Reverse Breakdown Voltage | $V_{BR}$  | $I_t = 1mA$<br>Any I/O pin to ground                | 6       |         |         | V     |
| Reverse Leakage Current   | $I_R$     | $V_{RWM} = 5V, T=25°C$<br>Any I/O pin to ground     |         |         | 1       | μA    |
| Clamping Voltage          | $V_C$     | $I_{pp} = 1A, tp = 8/20μs$<br>Any I/O pin to ground |         |         | 15      | V     |
| Junction Capacitance      | $C_j$     | $V_R = 0V, f = 1MHz$<br>Between I/O pins            |         | 0.30    | 0.4     | pF    |
| Junction Capacitance      | $C_j$     | $V_R = 0V, f = 1MHz$<br>Any I/O pin to ground       |         |         | 0.8     | pF    |

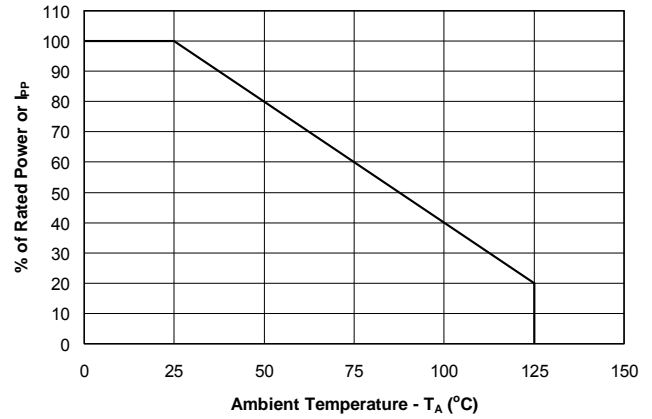
PROTECTION PRODUCTS

Typical Characteristics

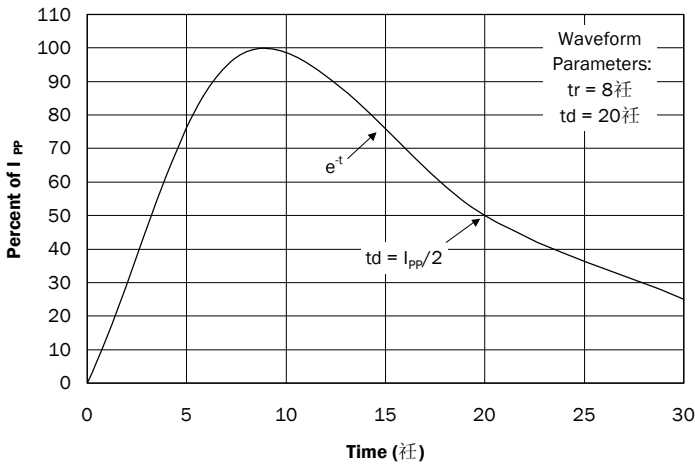
Non-Repetitive Peak Pulse Power vs. Pulse Time



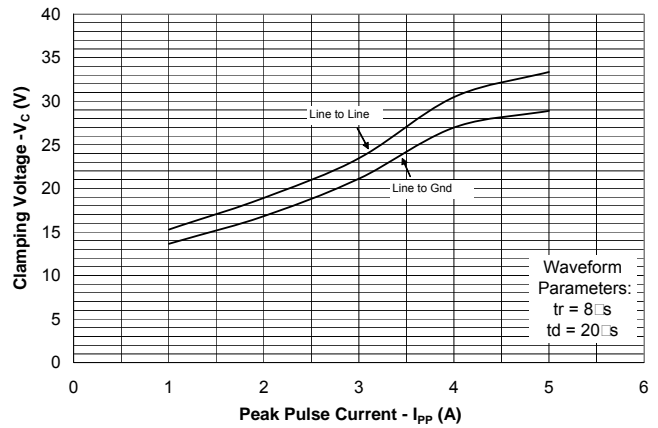
Power Derating Curve



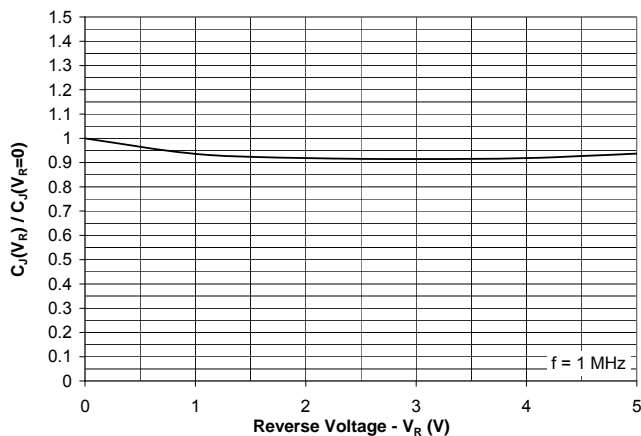
Pulse Waveform



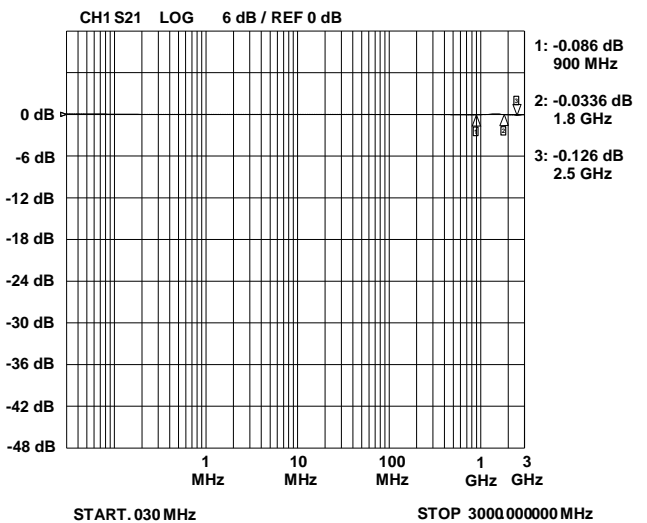
Clamping Voltage vs. Peak Pulse Current (Between any I/O and Ground)

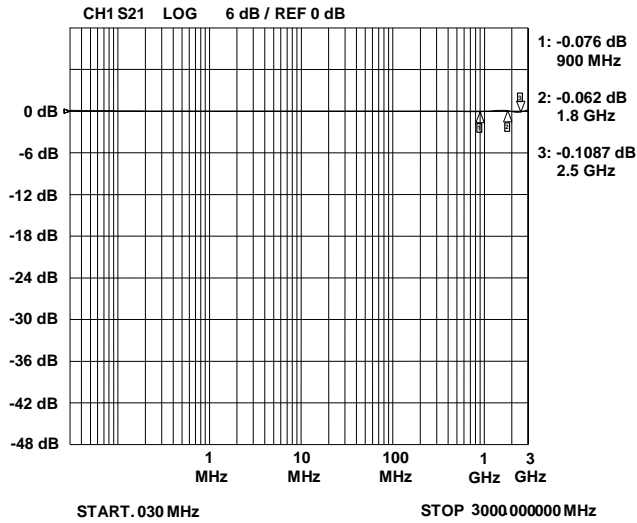


Normalized Capacitance vs. Reverse Voltage



Insertion Loss S21 - I/O to GND



**PROTECTION PRODUCTS**
**Typical Characteristics (Con't)**
**Insertion Loss S21 - I/O to I/O**


**PROTECTION PRODUCTS**
**Applications Information**
**Design Recommendations for HDMI Protection**

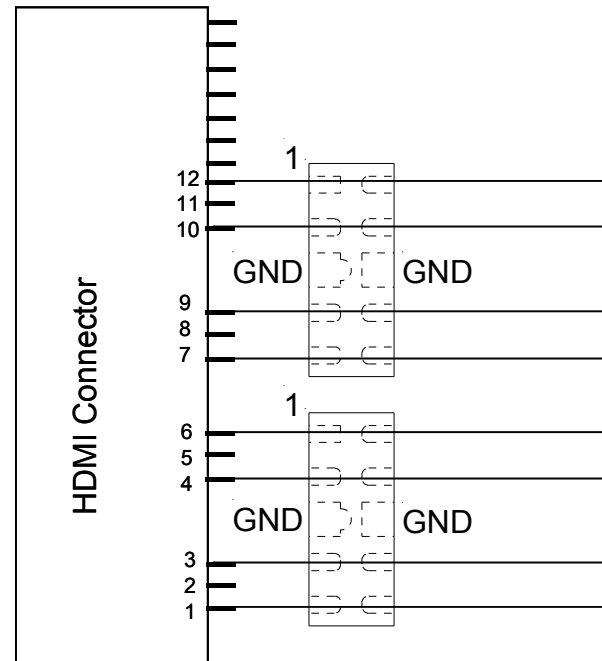
Adding external ESD protection to HDMI ports can be challenging. First, ESD protection devices have an inherent junction capacitance. Furthermore, adding even a small amount of capacitance will cause the impedance of the differential pair to drop. Second, large packages and land pattern requirements cause discontinuities that adversely affect signal integrity. The RClamp0524PA and RClamp0522P are specifically designed for protection of high-speed interfaces such as HDMI. They present <math><0.4\text{pF}</math> capacitance between the pairs while being rated to handle  $>\pm 8\text{kV}$  ESD contact discharges ( $>\pm 15\text{kV}$  air discharge) as outlined in IEC 61000-4-2. Each device is in a leadless SLP package that is less than 1.1mm wide. They are designed such that the traces flow straight through the device. The narrow package and flow-through design reduces discontinuities and minimizes impact on signal integrity. This becomes even more critical as signal speeds increase.

**Pin Configuration**

Figure 1 is an example of how to route the high speed differential traces through the RClamp0524PA. The solid line represents the PCB trace. The PCB traces are used to connect the pin pairs for each line (pin 1 to pin 10, pin 2 to pin 9, pin 4 to pin 7, pin 5 to pin 6). For example, line 1 enters at pin 1 and exits at Pin 10 and the PCB trace connects pin 1 and 10 together. This is true for lines connected at pins 2, 4, and 5 also. Ground is connected at pins 3 and 8. One large ground pad should be used in lieu of two separate pads. The same layout rules apply for the RClamp0522P.

**TDR Measurements for HDMI**

The combination of low capacitance, small package, and flow-through design means it is possible to use these devices to meet the HDMI impedance requirements of 100 Ohms  $\pm 15\%$  without any PCB board modification. Figure 3 shows a typical impedance test result for a TDR risetime of 200ps using a Semtech evaluation board with 100 Ohm traces throughout. Measurements were taken using a TDR method as outlined in the HDMI Compliance Test Specification (CTS). In each



**Figure 1. Flow through Layout Using RClamp0524PA**

**PROTECTION PRODUCTS**

**Applications Information**

case, the device meets the HDMI CTS requirement of 100 Ohm  $\pm$ 15% with plenty of margin.

Figure 3 shows a typical HDMI 1.3 eye pattern at 1080p resolution. As shown there are no violations of the eye pattern with RClamp0524PA in the circuit. The RClamp0524PA may also be used to protect the remaining lines (I2C, CEC, and hot plug). Figure 4 shows the complete protection solution.

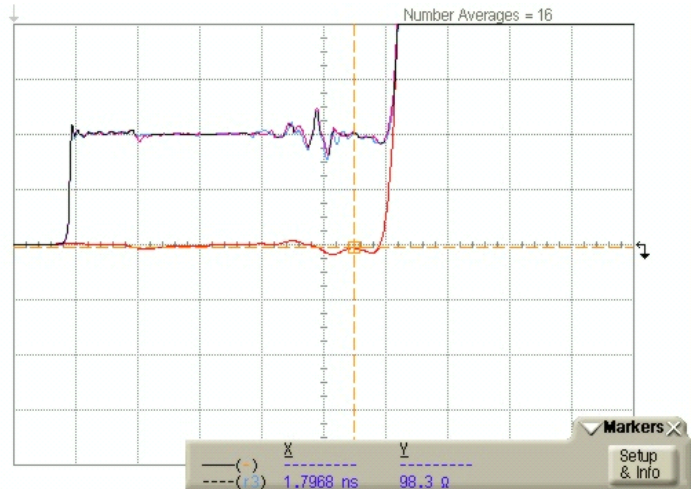
**Layout Guidelines for Optimum ESD Protection**

Good circuit board layout is critical not only for signal integrity, but also for effective suppression of ESD induced transients. For optimum ESD protection, the following guidelines are recommended:

- Place the device as close to the connector as possible. This practice restricts ESD coupling into adjacent traces and reduces parasitic inductance.
- The ESD transient return path to ground should be kept as short as possible. Whenever possible, use multiple micro vias connected directly from the device ground pad to the ground plane.
- Avoid running critical signals near board edges.

**Protecting MDDI Ports with RClamp0524PA and RClamp0522P**

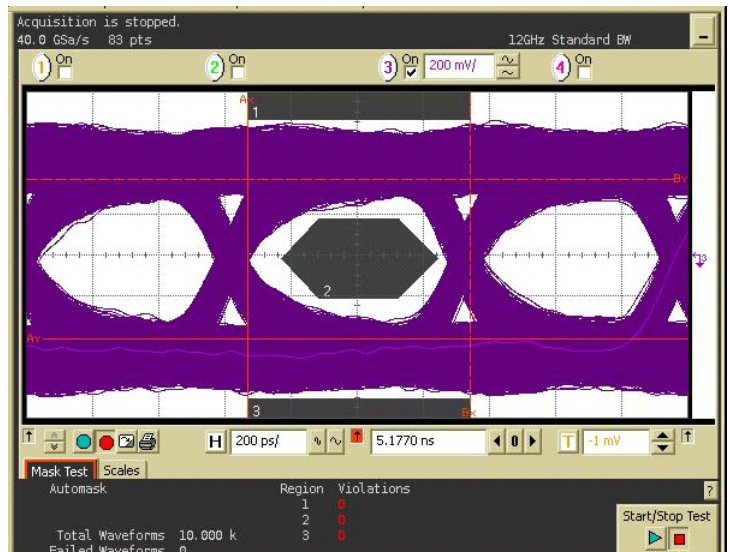
The small package size and low capacitance of the RClamp0522P and RClamp0524PA make them ideal for high-speed lines in portable applications. One such application is the protection of MDDI ports in cellular phones. MDDI is a serial data interface operating at 480Mb/s per line pair. The lines are scalable for increased speed and display resolution. A MDDI port protection example is shown in Figure 5. The RClamp0524PA is used to protect two differential line pairs while an RClamp0522P is used to protect the MDDI strobe lines. Note that devices are used on both the main board and LCD side of the MDDI port. Devices on the main board are needed to protect the MDDI controller in the Baseband processor and devices on the LCD board to protect MDDI controller in LCD module. A single line TVS such as the uClamp0501P is used to protect the MDDI power line. The protection devices should be placed close to the connector of each board. Traces are routed directly through each device, minimizing parasitic inductance. Connections to the ground plane should be made with multiple micro vias when possible.



|               |      |        |
|---------------|------|--------|
|               |      |        |
| <b>X-axis</b> | 1.79 | (nsec) |
| <b>Y-axis</b> | 98.3 | (Ohm)  |

**Figure 2 - TDR Measurement with 200ps risetime using Semtech Evaluation Board**

Note: Measurements were taken on SLP HDMI EVAL Rev C Board that has 100Ω differential traces impedance throughout (No trace Compensation).



**Figure 3 - Typical HDMI 1.3 Eye Pattern (1080p) with RClamp0524PA**

PROTECTION PRODUCTS

Applications Information

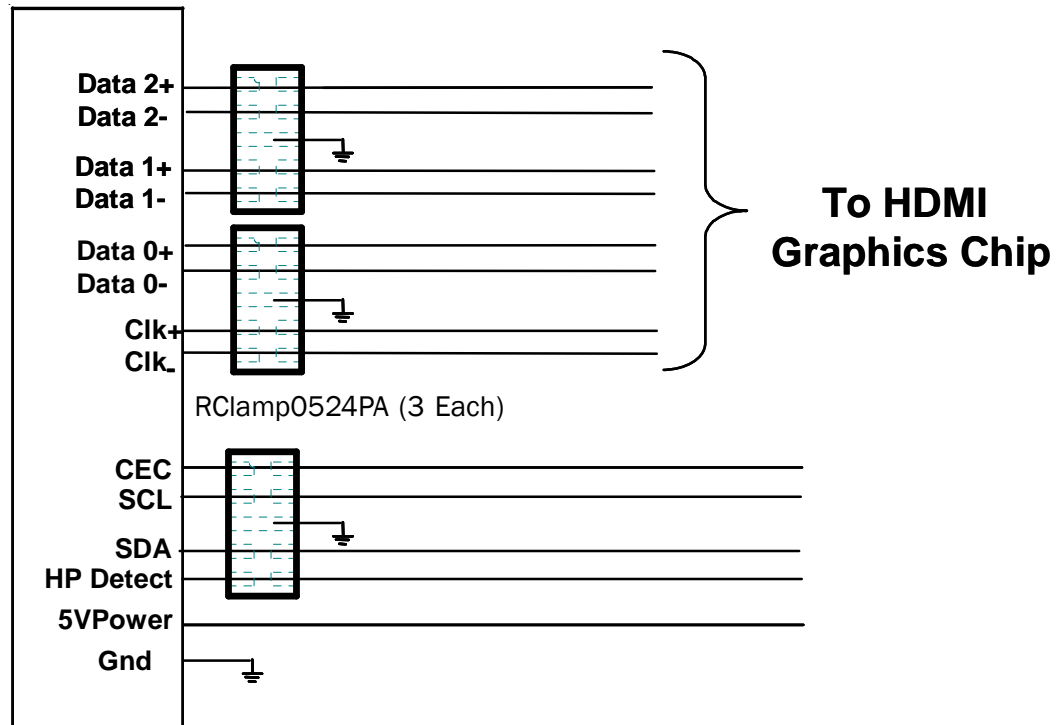


Figure 4. HDMI Protection

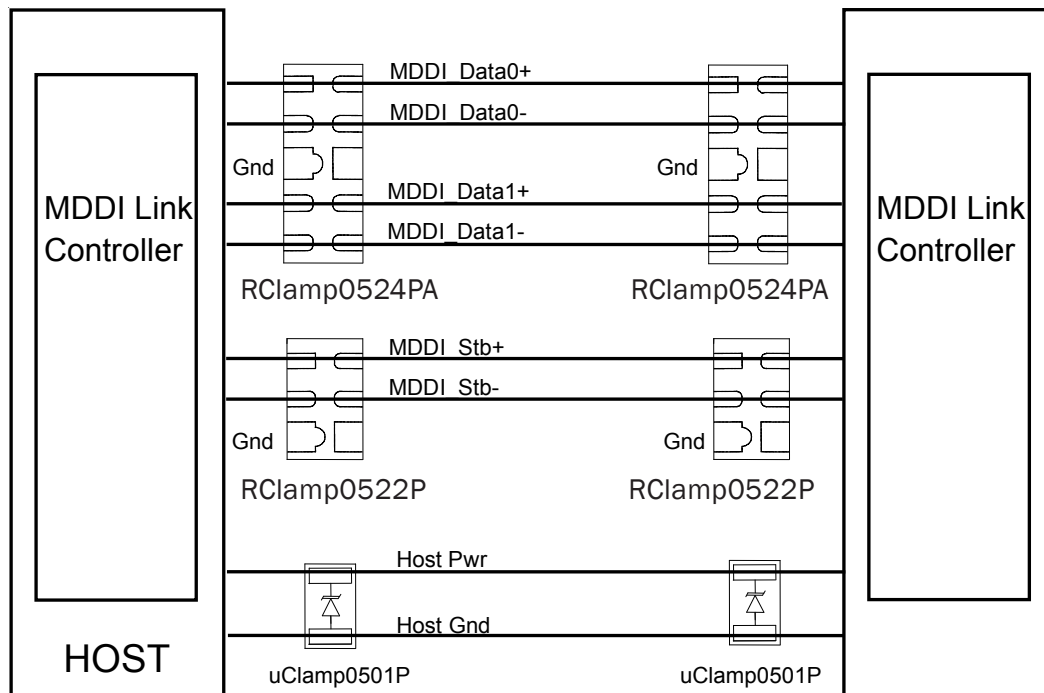
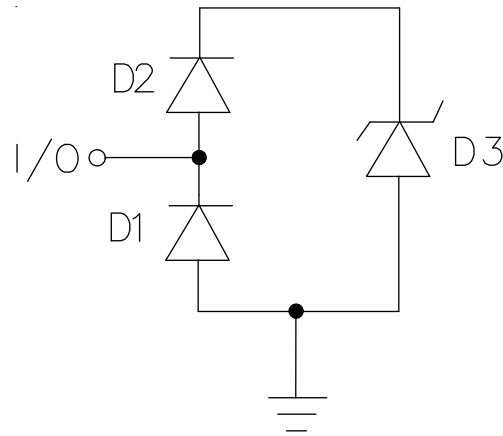
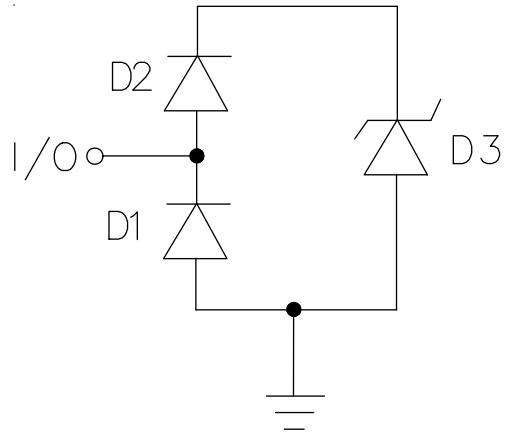


Figure 5. MDDI Port Protection

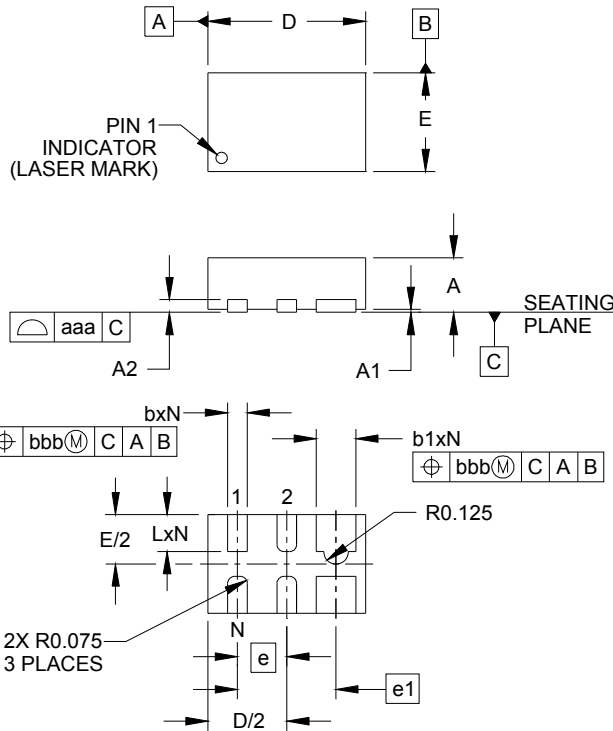



**RClamp0522P Spice Model**

| <b>RClamp0522P Spice Parameters</b> |             |           |           |           |
|-------------------------------------|-------------|-----------|-----------|-----------|
| <b>Parameter</b>                    | <b>Unit</b> | <b>D1</b> | <b>D2</b> | <b>D3</b> |
| IS                                  | Amp         | 1E-20     | 1E-20     | 2E-12     |
| BV                                  | Volt        | 100       | 100       | 8.2       |
| VJ                                  | Volt        | 0.83      | 0.83      | 0.6       |
| RS                                  | Ohm         | 1.5       | 0.6       | 0.2       |
| IBV                                 | Amp         | 1E-3      | 1E-3      | 1E-3      |
| CJO                                 | Farad       | 0.25E-12  | 0.25E-12  | 56E-12    |
| TT                                  | sec         | 2.541E-9  | 2.541E-9  | 2.541E-9  |
| M                                   | --          | 0.01      | 0.01      | 0.23      |
| N                                   | --          | 1.1       | 1.1       | 1.1       |
| EG                                  | eV          | 1.11      | 1.11      | 1.11      |

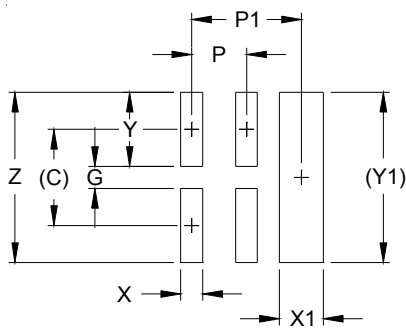

**RClamp0524PA Spice Model**

| <b>RClamp0524PA Spice Parameters</b> |             |            |            |            |
|--------------------------------------|-------------|------------|------------|------------|
| <b>Parameter</b>                     | <b>Unit</b> | <b>D1</b>  | <b>D2</b>  | <b>D3</b>  |
| IS                                   | Amp         | 4.6722E-5  | 1E-20      | 1.0017E-12 |
| BV                                   | Volt        | 100        | 100        | 8.3312     |
| VJ                                   | Volt        | 1.0508     | 1.0508     | 0.75       |
| RS                                   | Ohm         | 1.2        | 0.41766    | 0.3        |
| IBV                                  | Amp         | 1E-4       | 1E-4       | 3.1155E-3  |
| CJO                                  | Farad       | 1.6031E-13 | 1.6031E-13 | 1.0555E-10 |
| TT                                   | sec         | 2.541E-9   | 2.541E-9   | 2.541E-9   |
| M                                    | --          | 0.1        | 0.1        | 0.33194    |
| N                                    | --          | 5          | 0.60891    | 4.995      |
| IKF                                  | Amp         | 0          | 959.36     | 1.1141E-9  |
| EG                                   | eV          | 1.11       | 1.11       | 1.11       |

**PROTECTION PRODUCTS**
**Outline Drawing - SLP1610P4**


| DIM | INCHES   |      |      | MILLIMETERS |      |      |
|-----|----------|------|------|-------------|------|------|
|     | MIN      | NOM  | MAX  | MIN         | NOM  | MAX  |
| A   | .020     | .023 | .026 | 0.50        | 0.58 | 0.65 |
| A1  | 0.00     | .001 | .002 | 0.00        | 0.03 | 0.05 |
| A2  | (.005)   |      |      | (0.13)      |      |      |
| b   | .006     | .008 | .010 | 0.15        | 0.20 | 0.25 |
| b1  | .014     | .016 | .018 | 0.35        | 0.40 | 0.45 |
| D   | .059     | .063 | .067 | 1.50        | 1.60 | 1.70 |
| E   | .035     | .039 | .043 | 0.90        | 1.00 | 1.10 |
| e   | .020 BSC |      |      | 0.50 BSC    |      |      |
| e1  | .039 BSC |      |      | 1.00 BSC    |      |      |
| L   | .012     | .015 | .017 | 0.30        | 0.38 | 0.43 |
| N   | 4        |      |      | 4           |      |      |
| aaa | .003     |      |      | 0.08        |      |      |
| bbb | .004     |      |      | 0.10        |      |      |

NOTES:  
 1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).

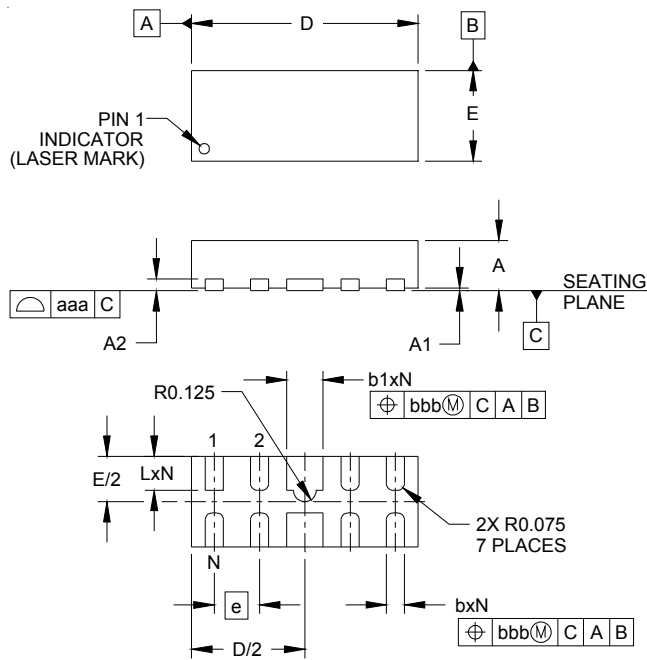
**Land Pattern - SLP1610P4**


| DIM | DIMENSIONS |             |
|-----|------------|-------------|
|     | INCHES     | MILLIMETERS |
| C   | (.034)     | (0.87)      |
| G   | .007       | 0.19        |
| P   | .020       | 0.50        |
| P1  | .039       | 1.00        |
| X   | .008       | 0.20        |
| X1  | .016       | 0.40        |
| Y   | .027       | 0.68        |
| Y1  | (.061)     | (1.55)      |
| Z   | .061       | 1.55        |

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 CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.

PROTECTION PRODUCTS

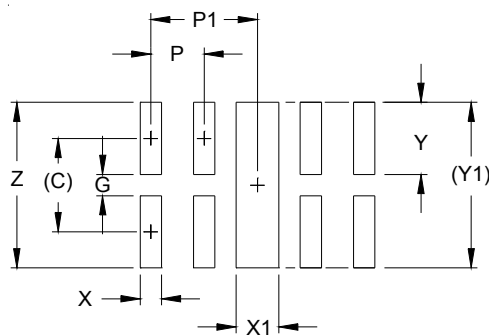
Outline Drawing - SLP2510P8



| DIM | INCHES |          |      | MILLIMETERS |          |       |
|-----|--------|----------|------|-------------|----------|-------|
|     | MIN    | NOM      | MAX  | MIN         | NOM      | MAX   |
| A   | .020   | .023     | .026 | 0.50        | 0.58     | 0.65  |
| A1  | 0.00   | .001     | .002 | 0.00        | 0.03     | 0.05  |
| A2  |        | (.005)   |      |             | (0.13)   |       |
| b   | .006   | .008     | .010 | 0.15        | 0.20     | 0.25  |
| b1  | .014   | .016     | .018 | 0.35        | 0.40     | 0.45  |
| D   | .094   | .098     | .102 | 2.40        | 2.50     | 2.60  |
| E   | .035   | .039     | .043 | 0.90        | 1.00     | 1.10  |
| e   |        | .020 BSC |      |             | 0.50 BSC |       |
| L   | .012   | .015     | .017 | 0.30        | 0.38     | 0.425 |
| N   |        | 8        |      |             | 8        |       |
| aaa |        | .003     |      |             | 0.08     |       |
| bbb |        | .004     |      |             | 0.10     |       |

NOTES:  
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Land Pattern - SLP2510P8



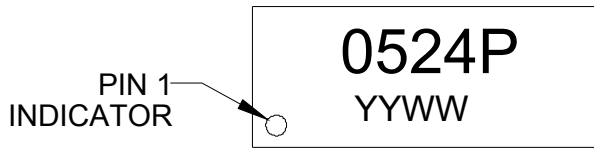
| DIM | DIMENSIONS |             |
|-----|------------|-------------|
|     | INCHES     | MILLIMETERS |
| C   | (.034)     | (0.875)     |
| G   | .008       | 0.20        |
| P   | .020       | 0.50        |
| P1  | .039       | 1.00        |
| X   | .008       | 0.20        |
| X1  | .016       | 0.40        |
| Y   | .027       | 0.675       |
| Y1  | (.061)     | (1.55)      |
| Z   | .061       | 1.55        |

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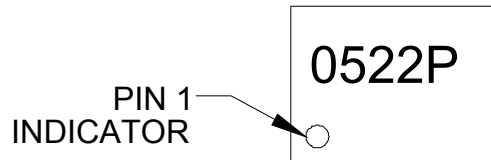
**PROTECTION PRODUCTS**

**Marking Codes**

**RClamp0524PA**

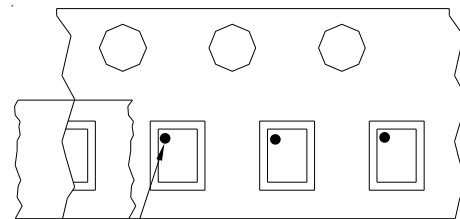
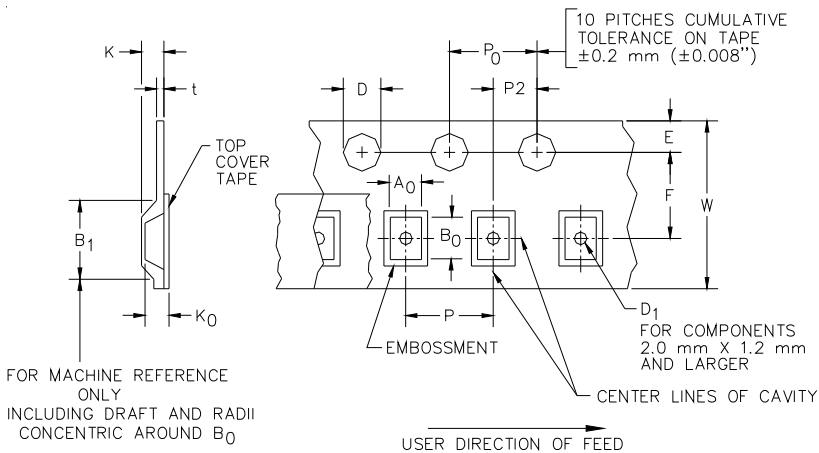


**RClamp0522P**



YYWW = Date Code

**Tape and Reel Specification**



Pin 1 Location

User Direction of feed

**Device Orientation in Tape**

| Part Number  | A0              | B0              | K0              |
|--------------|-----------------|-----------------|-----------------|
| RClamp0522P  | 1.30 +/-0.05 mm | 1.75 +/-0.05 mm | 0.70 +/-0.05 mm |
| RClamp0524PA | 1.23 +/-0.05 mm | 2.70 +/-0.05 mm | 0.70 +/-0.05 mm |

| Tape Width | B, (Max) | D                          | D1              | E               | F              | K (MAX) | P             | P0            | P2             | T(MAX) | W                              |
|------------|----------|----------------------------|-----------------|-----------------|----------------|---------|---------------|---------------|----------------|--------|--------------------------------|
| 8 mm       | 4.2 mm   | 1.5 + 0.1 mm<br>- 0.0 mm ) | 0.5 mm<br>±0.05 | 1.750±.10<br>mm | 3.5±0.05<br>mm | 2.4 mm  | 4.0±0.1<br>mm | 4.0±0.1<br>mm | 2.0±0.05<br>mm | 0.4 mm | 8.0 mm<br>+ 0.3 mm<br>- 0.1 mm |

**Contact Information**

Semtech Corporation  
Protection Products Division  
200 Flynn Road, Camarillo, CA 93012  
Phone: (805)498-2111 FAX (805)498-3804

**PROTECTION PRODUCTS**

| Date     | Description  |
|----------|--|
| 2/26/10  | Release of "A" Specification<br>Note that electrical characteristics match<br>RClamp0544T  |
| 3/8/2010 | Change electrical specification & typ curves back<br>to match original RClamp0522/24P<br>Add HDMI apps diagram<br>Update TDR & add EPT diagrams<br>Updated ESD specification on page 1 |
| 2/23/11  | Remove "A" suffix from RClamp0522P   |
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